

## Task 38-Solar Air-Conditioning and Refrigeration Workshop

Heat rejection

Orlando, FL.

27/01/2010

Lars Reinholdt



# Content

## Thermal driven cooling

- A little bit of theory
- How good are the systems?
- The challenge of parasitic loads with focus on heat rejection

## Theoretical maximum COP (coefficient Of Performance)

$$COP \equiv \frac{\text{Cooling capacity}}{\text{Energy used}}$$

Heat pump application  **$COP_{HP} = COP + 1$**

Mechanical  
driven

$$COP_{ideal,mechanical} = \frac{T_{cold}}{T_{ambient} - T_{cold}}$$

Thermal driven

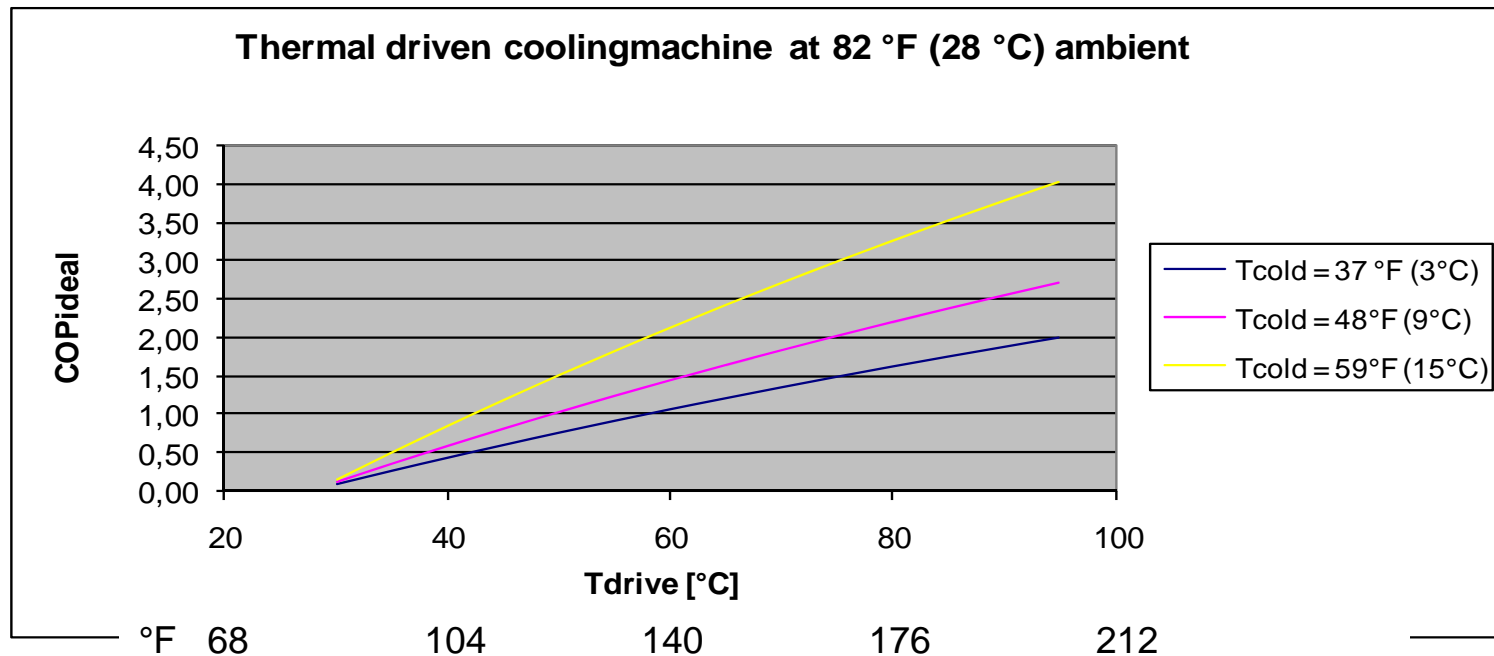
$$COP_{ideal,thermal} = \frac{T_{cold}}{T_{drive}} * \frac{T_{drive} - T_{ambient}}{T_{ambient} - T_{cold}}$$

$$COP_{th} \equiv \frac{\text{Cooling capacity}}{\text{Thermal energy used}}$$

$$COP_{el} \equiv \frac{\text{Cooling capacity}}{\text{Electrical energy used}}$$

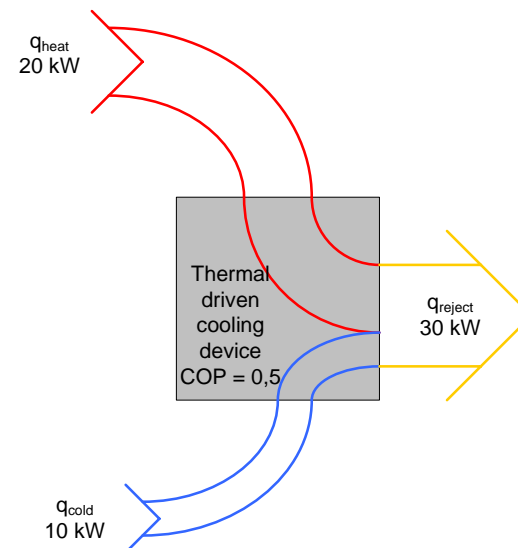
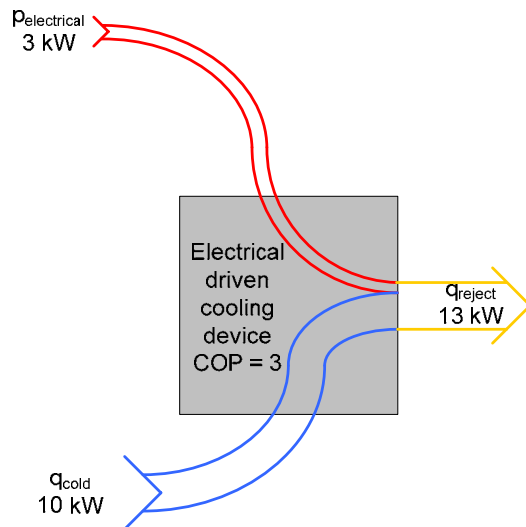
# Theoretical maximum COP

| Mechanical driven <i>cooling</i> machine |                                 |      |
|--|---------------------------------|------|
| $T_{\text{cold}}$<br>°F (°C)             | $T_{\text{ambient}}$<br>°F (°C) | COP  |
| 37 (3)                                   | 82 (28)                         | 11,0 |
| 48 (9)                                   | 82 (28)                         | 14,8 |
| 59 (15)                                  | 82 (28)                         | 22,2 |

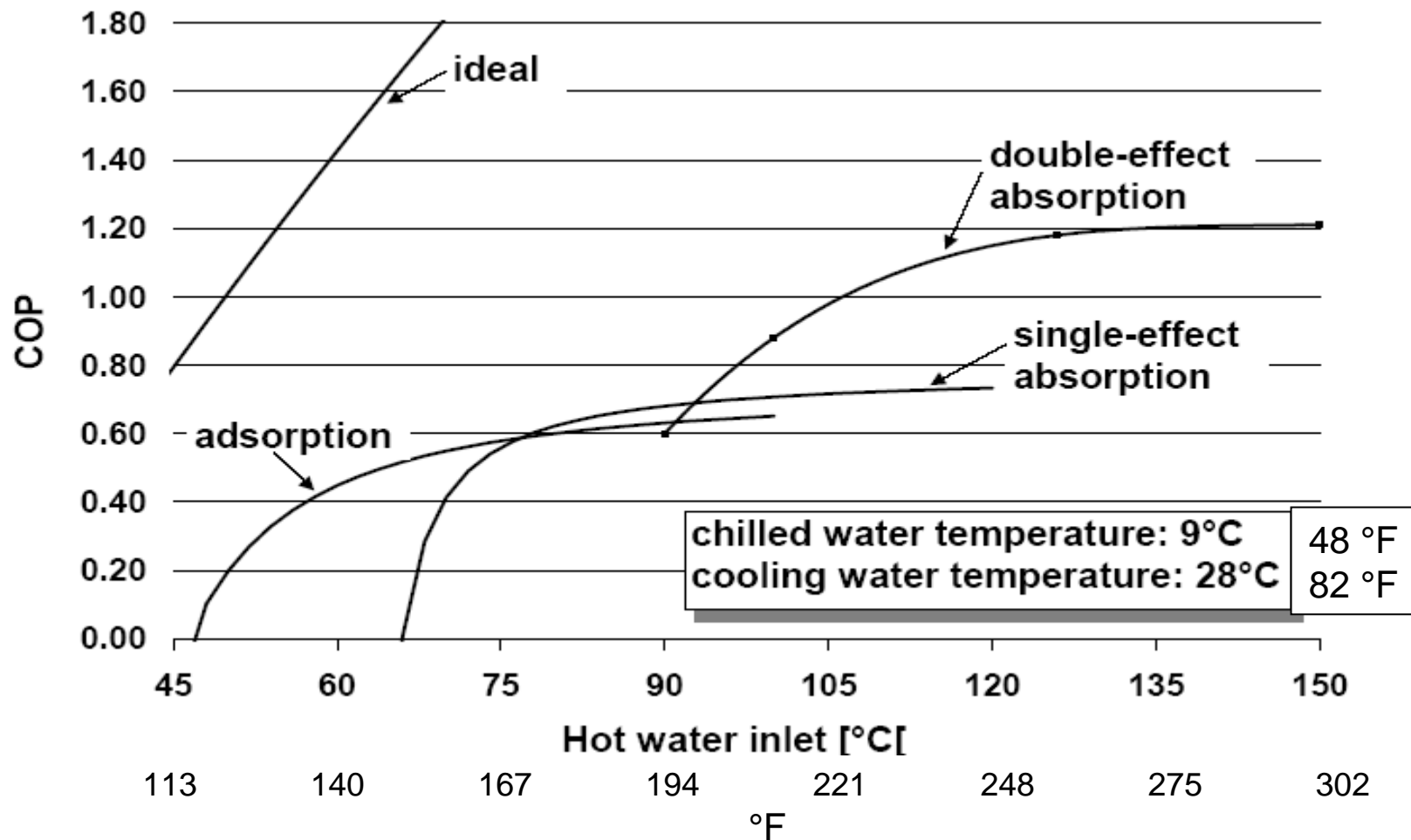


## Mechanical <> thermal driven

- COP has a large impact on the amount of heat to be rejected (cooling operation) or delivered as heat (heat pump). This can have a great impact on the electrical power consumption.

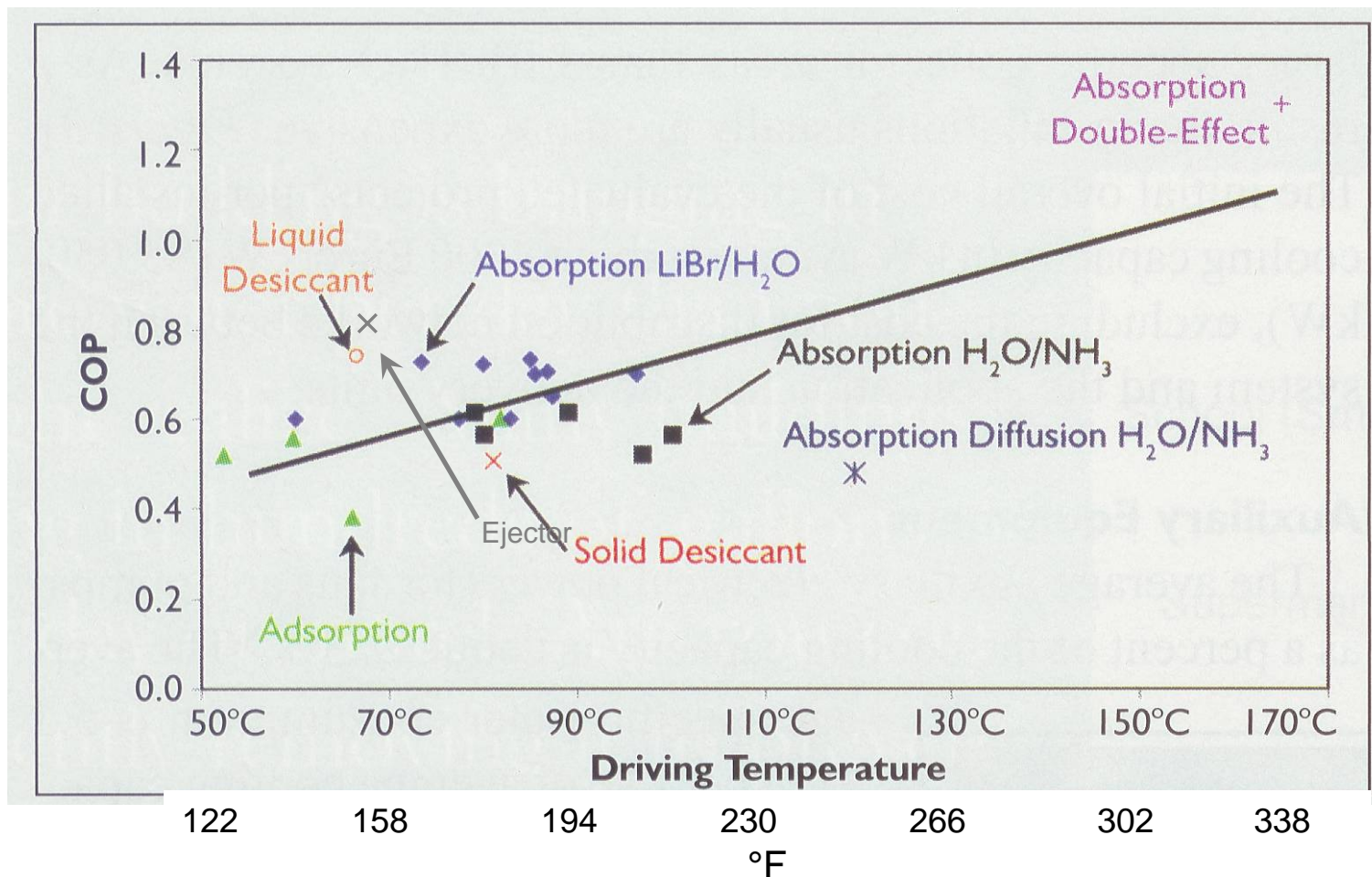


# How good are the systems



# European demonstration systems

Thermal COP



## Parasitic load and the challenge in heat rejection

As stated the amount of electrical power needed for operating the auxiliary equipment can be expressed as

$$COP_{el} \equiv \frac{\textit{Cooling capacity}}{\textit{Electrical energy used}}$$

Often the reduction in electrical consumption is the main argument when deciding to use solar driven cooling and air conditioning.

Heat rejection is often the major contributor to the electrical consumption and can account for up to more than 50% of the total consumption.

The reasons are

- Large quantities of heat has to be rejected > Large pumps + fans in cooling tower/dry cooler
- In order to reach high cooling capacities low cooling water temperature and high flow is needed
- Often only the power consumption for the controlsystem and small internal pumps are included in data sheets

## Control strategy

The control strategy has a great impact on the power consumption

- Traditional control: Lowering the driving temperature
- Alternative strategy: Raise the heat rejection temperature.

Up to 50% reduction in power consumption has been seen!

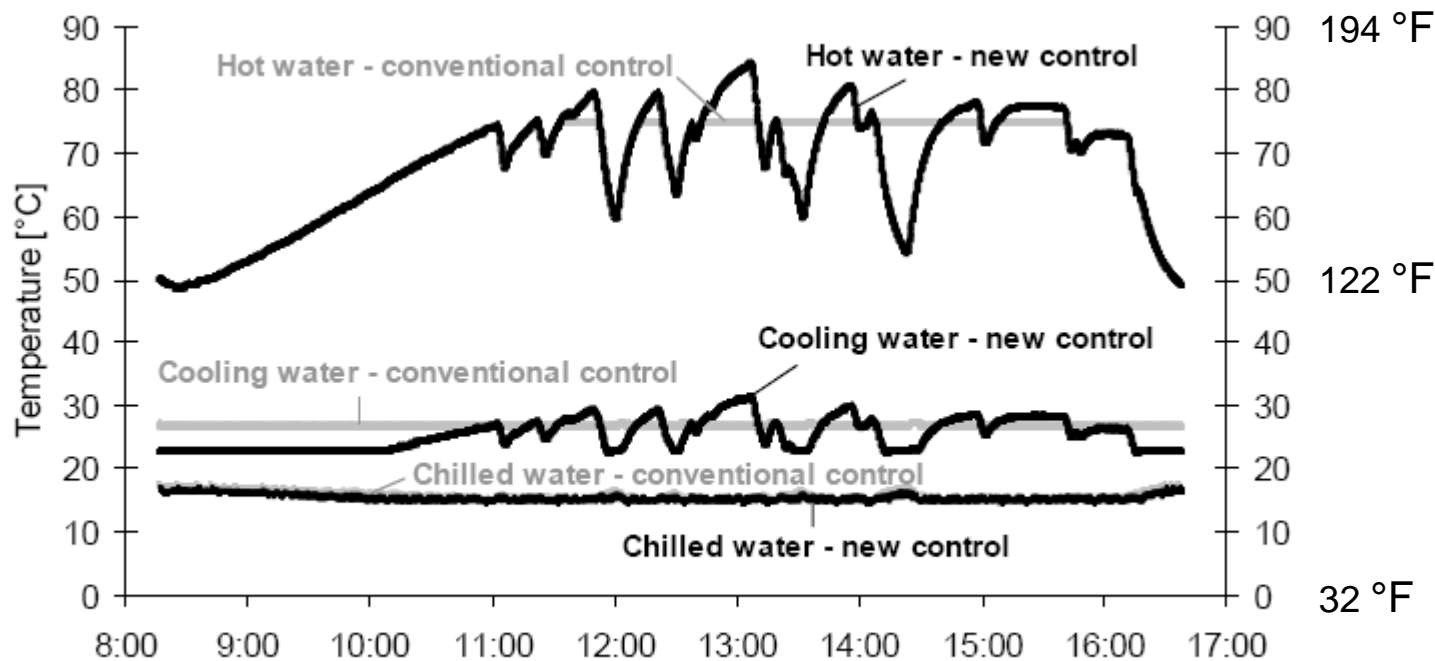
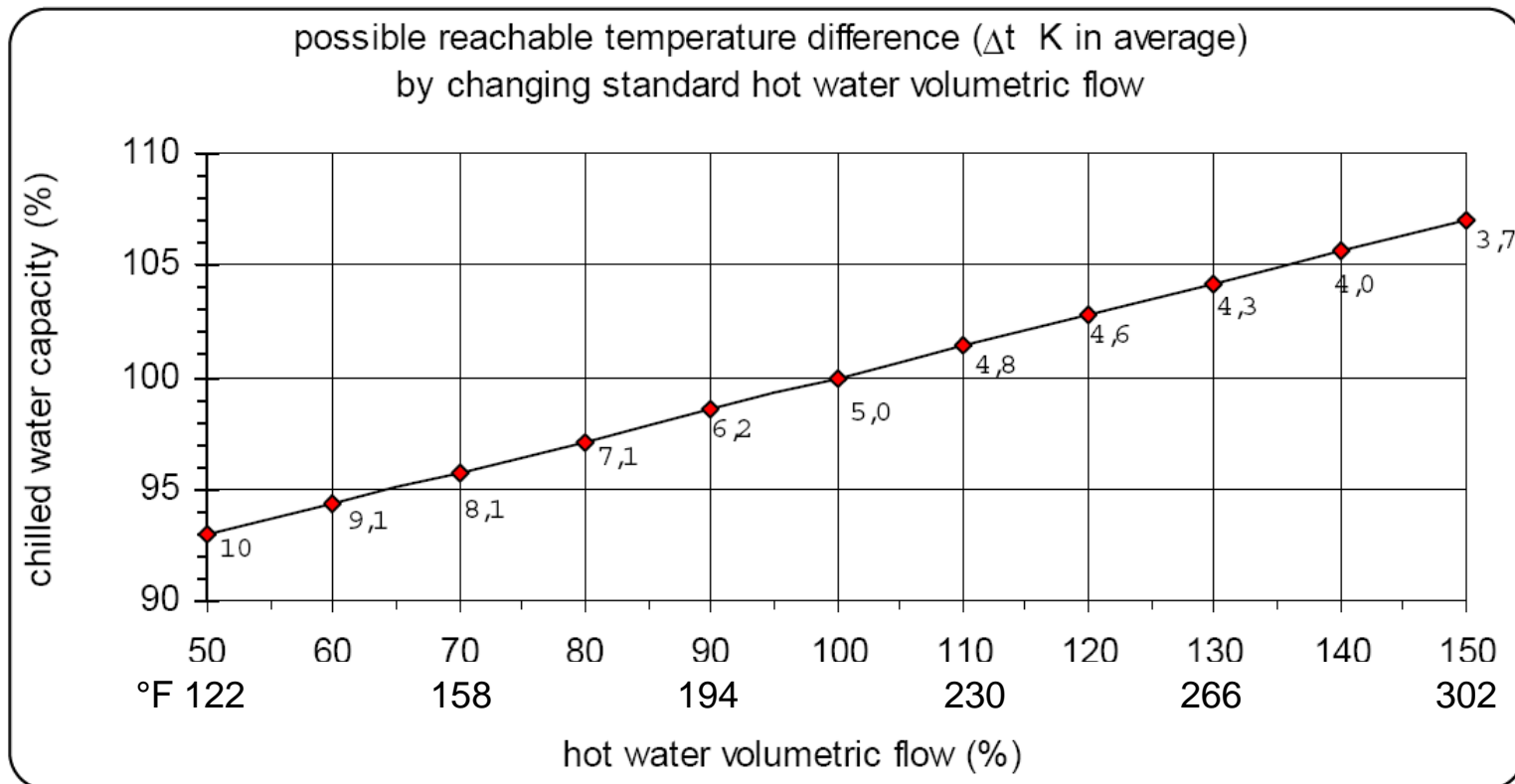


Fig. 4. External temperatures for a cloudy day in Berlin.

## Change in running conditions

Change of flow of driving hot water resulting in changing temperature change  
(example: Adsorption machine):



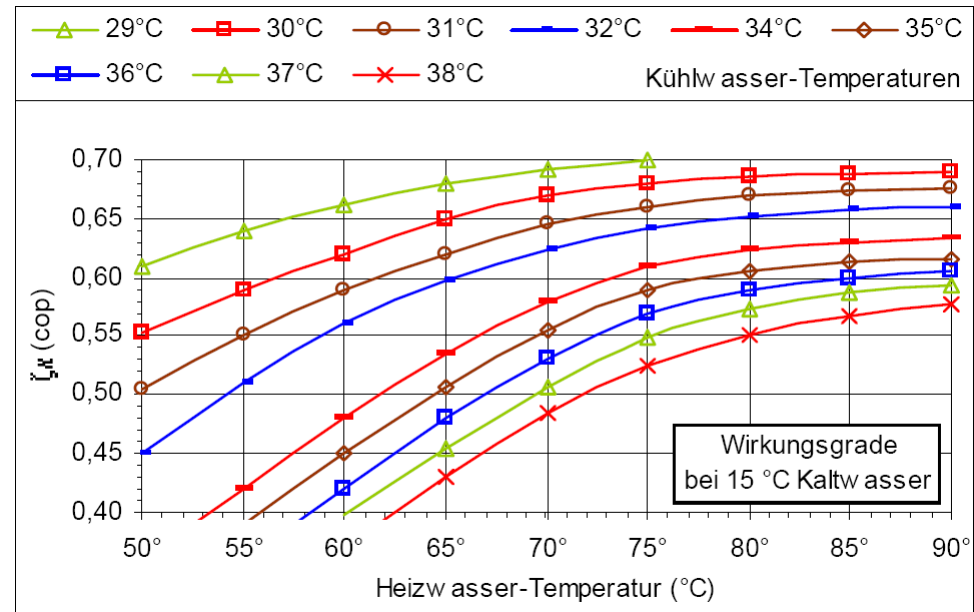
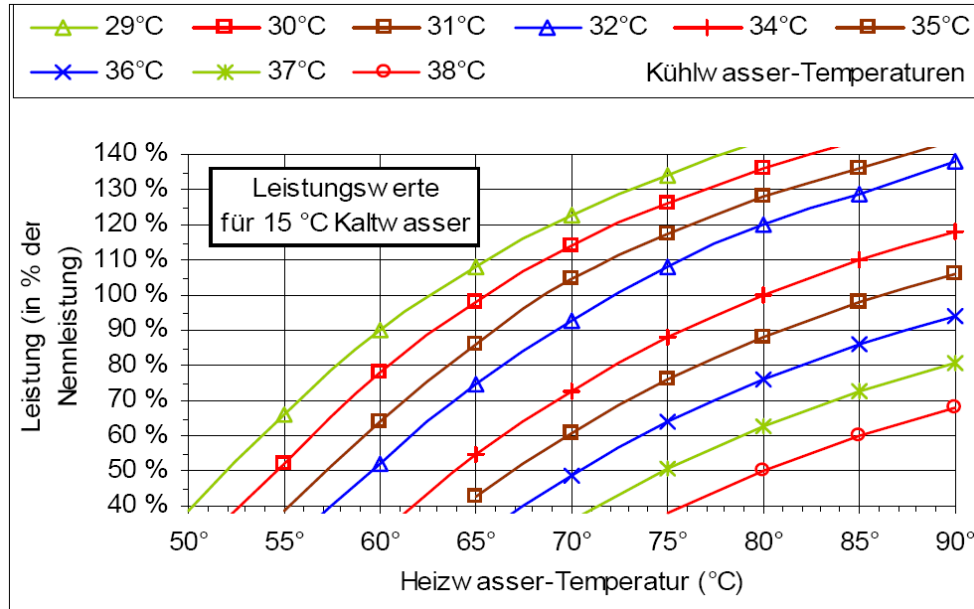
# Change in running conditions



Example: adsorption

cold side:

68F (20°C) > 59F (15°C)



| C  | F   |
|----|-----|
| 29 | 84  |
| 30 | 86  |
| 31 | 88  |
| 32 | 90  |
| 33 | 91  |
| 34 | 93  |
| 35 | 95  |
| 36 | 97  |
| 37 | 99  |
| 38 | 100 |

| C  | F   |
|----|-----|
| 50 | 122 |
| 55 | 131 |
| 60 | 140 |
| 65 | 149 |
| 70 | 158 |
| 75 | 167 |
| 80 | 176 |
| 85 | 185 |
| 90 | 194 |

Thank you

Lars Reinholdt  
lre@dti.dk